**A Review of the Cape Cod National Seashore Prototype**
**Long-term Ecosystem Monitoring Program**
November 25, 2002

## I. Background

Knowing the condition of natural resources in national parks is fundamental to the Service's ability to protect and manage parks. National Park managers across the country are confronted with increasingly complex and challenging issues, and managers are increasingly being asked to provide scientifically credible data to defend management actions. A long-term ecological monitoring program is necessary to enable managers to make better informed management decisions, to provide early warning of abnormal conditions in time to develop effective mitigation measures, to convince other agencies and individuals to make decisions benefiting parks, to satisfy certain legal mandates, provide a means of tracking resource condition and measuring performance, and to provide reference data for relatively pristine sites for comparison with data collected outside of parks by other agencies. The overall purpose of monitoring is to develop broadly based, scientifically sound information on the current status and long term trends in the composition, structure, and function of the park ecosystem. Use of monitoring information will increase confidence in manager's decisions and improve their ability to manage park resources.

One component of the National Park Service strategy for implementing ecological monitoring in approximately 270 parks that contain significant natural resources is a series of experimental or "prototype" long-term ecological monitoring (LTEM) programs. The prototype LTEM programs were established in the early 1990s primarily in an attempt to learn how to design scientifically credible and cost-effective monitoring programs in ecological settings of major importance to a number of NPS units. Much of the design, development, and testing of monitoring protocols is conducted in prototype parks in cooperation with scientists from the U.S. Geological Survey.

In FY 2000, as part of the Natural Resource Challenge, the NPS implemented a new strategy for natural resource monitoring in parks with significant natural resources, whereby 270 parks with significant natural resources (including all of the prototype parks) were organized into 32 networks linked by geography and shared natural resource characteristics. The network approach will facilitate collaboration, information sharing, and economies of scale in natural resource monitoring, and will provide parks with a minimum infrastructure for initiating natural resource monitoring that can be built upon in the future. As part of a new framework for inventory and monitoring, prototype LTEM programs are nested within a network structure, and provide expertise and support to other parks in their network as well as providing protocols and expertise to parks throughout the NPS. Because of higher funding and staffing levels, as well as USGS involvement and funding in program design and protocol development, the prototypes are expected to serve as "centers of excellence" that will be able to do more extensive and in-depth monitoring and continue research and development work to benefit other parks. Prototype LTEM programs possess a wealth of experience and expertise related to the development and implementation of ecological monitoring that can greatly benefit other parks throughout the NPS. The prototype programs provide mentoring assistance to other parks undertaking long-term ecological monitoring, and provide technical assistance to staff from other parks on a wide variety of technical issues related to monitoring, including conceptual design, database management, data integration and analysis, and reporting of monitoring findings.
The tremendous variability among parks in ecological conditions, sizes, and management capabilities represent significant problems for any attempt to institutionalize ecological monitoring throughout the NPS. To develop monitoring expertise throughout this range of

ecological and managerial diversity, natural resource park units were grouped into 10 major biogeographic areas or biomes, and one park from each major biome was then selected to serve as a prototype LTEM program for that biome.

**II. Objectives of the Review**

This review of the Cape Cod National Seashore prototype program by a panel of NPS, USGS, and Woods Hole Oceanographic Institute scientists was undertaken to provide constructive recommendations for improvements to the program at the time of transition from the research and development phase to the operational phase. The key questions being addressed by the review panel are as follows:

- ✓ How complete is the initial design developed by USGS during the Research and Development phase?
- ✓ What needs to be done to complete the initial design phase?
- ✓ How can the existing program be modified to improve performance or comprehension for future operations as the program transitions to the operational phase?
- ✓ What should happen to make the program better over the next 5-10 years?
- ✓ What information do managers use now?
- ✓ What information do managers need that is not available?

The review was forward-looking: what additions or modifications to the program should be undertaken so that park managers receive the type of information they need to adequately understand and manage the parks and work with their neighbors? The various protocols developed by USGS scientists and collaborators have already been formally peer-reviewed through the review process of the Patuxent Wildlife Research Center, and the panel members therefore did not review the protocols themselves. Instead, the focus was on whether the park was receiving scientifically credible, relevant information that addressed high-priority needs and helped the management of the park, and the implementation of the program by NPS staff.

The original proposal for the Cape Cod NS prototype program was written in 1993, but partial funding was not received until 1996. The prototype program is a collaborative effort between NPS and USGS, with USGS scientists responsible for the initial design of the long-term monitoring program and the development of sampling protocols. Once protocols have been developed, the operational monitoring tasks (including data analysis and reporting) are assumed by NPS staff. Development and testing of several of the monitoring protocols has been directed by Dr. Charles Roman and other scientists from the USGS with USGS funding, whereas other protocols for monitoring were funded and developed primarily by NPS staff. Six protocols have been completed, peer-reviewed, and provided to the NPS for implementation, with 11 more expected to be completed, reviewed, and delivered during FY 2003. An additional 16 protocols are still in varying stages of development. The NPS has recently hired several permanent staff to implement the monitoring program. Thus, the program is at a transition of moving from a planning and design phase that included a large research component associated with protocol development, to an operation phase with most of the work conducted by permanent NPS staff.

The scientific review panel was comprised of six members:

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| Dr. Steven Fancy | NPS, National Monitoring Coordinator |
| Dr. Paul Geissler | USGS, Statistician and USGS Coordinator of the LTEM program |
| Dr. Graham Giese | Woods Hole Oceanographic Institute, Oceanographer Emeritus |
| Dr. Hilary Neckles | USGS, Ecologist, Patuxent Wildlife Research Center |
| Lisa Thomas | NPS, Program Coordinator, Prairie Cluster Prototype LTEM Program |
| Carl Zimmerman | NPS, Chief of Natural Resource Management, Assateague Island NS |

Review panel members were provided with the original conceptual framework document prepared by Dr. Charles Roman and Nels Barrett of the USGS in 1999, "*Conceptual Framework for the Development of Long-term Monitoring Protocols at Cape Cod National Seashore*", and with two update documents prepared by NPS staff working with the prototype program: "*Conceptual Framework, Monitoring Components, and Implementation of the Cape Cod National Seashore Prototype Long-Term Ecosystem Monitoring Program – October 2002 Status Report*" by Carrie Phillips, the program coordinator; and a "*2002 Update of the Conceptual Framework for the Development of Long-term Monitoring Protocols at Cape Cod National Seashore"* by Boland et al. Panel members read these overview documents prior to the site visit in November 2002. Copies of the completed protocols developed by USGS and NPS scientists and cooperators were posted on the Internet as reference material. Panel members attended a 4-day site visit to Cape Cod on November 4-8, 2002 that began with a 2-day Science Symposium and was attended by the superintendent, resource managers from Cape Cod NS and a number of other parks in the Northeast Region of the NPS, two of the network coordinators for networks of parks in the Southeast Region, NPS staff of the prototype program, USGS staff and cooperators that were involved in some of the protocol development, a number of scientists interested in studies in the Northeast Region, and several additional guests (see List of Participants). The first two days of the review was a Science Symposium that involved presentations by USGS and NPS staff and cooperators involved in designing the monitoring program. On Thursday, the panel met with the superintendent, assistant superintendent, and Chief of Natural Resources at CACO to obtain their input and assessment of the program and whether it was meeting each park's needs. There were two open discussion sessions with NPS staff involved with the prototype program to obtain additional input and recommendations for the program.

## III. Commendations

1. Cape Cod NS has developed an outstanding science program, which is not only a shining star within the NPS, but is also an excellent example of collaboration with other agencies, the scientific community and stakeholders. CACO is a leader in the new era of 'Science for Parks, Parks for Science'. Specific benefits of a strong science foundation are already apparent, such as clear articulation of conceptual models, incorporation of relevant environmental data (e.g. climate data, groundwater hydrology) as the context for ecological monitoring, and early consideration of statistical design issues.
2. The professionalism, competency and dedication of the staff, the monitoring coordinator, and chief of resource management are exemplary. Early efforts to establish clear lines of communication, roles, and responsibilities for the monitoring program within the context of existing park resource management programs demonstrate the staff's understanding of the need for integration of the monitoring program into the overall park management framework.
3. Dr. Roman and the USGS/BRD-led design team have done an excellent job during the initial planning and design phase. The development of each monitoring protocol has been guided by specific monitoring questions within a conceptual modeling framework. The objectives of the monitoring program emphasize the importance of understanding relationships among resources and threats and of forecasting potentially adverse changes. Conceptual models linking threats to park resources, stresses imposed by those threats, and responses by ecosystem components have provided a strong scientific foundation for each protocol. The use of this modeling framework has enabled identification of important monitoring variables and their direct application to current or potential management issues. Importantly, the conceptual models have also facilitated integration of the monitoring program across individual protocols. Part I of the

monitoring protocols provides outstanding discussion of the rationale and process used to select and refine monitoring protocols and discussion of sampling frequency, power and proposed analyses. The work will serve as a solid foundation for the CACO prototype and timely examples for I&M networks.

4. The number of valid and interesting protocols that have been developed or are in development attests to the dedication and accomplishment of those involved – USGS/BRD and university collaborators and LTEM staff scientists. The initial breadth of protocol development will serve the prototype program and Northeast Coastal and Barrier Network as the programs continue to grow and mature. Many of the issues addressed by the program are regional in nature and will likely serve as catalysts for collaborative long-term attention.
5. CACO is fulfilling the concept of a prototype park by involving coastal parks, including those outside of its network, in the planning and development of the sampling protocols. The symposium part of the review was an excellent example of how the CACO prototype program is making a concerted effort to share technology and information with other parks and stakeholders.
6. Park staff demonstrated a thorough understanding of park resources and the issues and challenges of monitoring the condition of those resources. Not only are staff extremely knowledgeable and innovative within their individual areas of disciplinary expertise, but they also understand the linkages among different protocols within the overall LTEM monitoring program. Protocol coordinators are proactive in determining how monitoring variables within a specific protocol may influence resources that are the focus of other protocols.
7. The interest and support of the superintendent, assistant superintendent, and Chief of Natural Resources has contributed substantially to the success of the program.

## IV. Recommendations

1. **Prioritization. Program leaders should prioritize among the many monitoring components that are being developed, provide a focus on essential information, and strike an appropriate balance between tactical and strategic monitoring.** The program is at a point in its development for careful consideration of the level of monitoring that can be sustained over the long-term. There are a number of reasons to begin from a conservative foundation, implementing the most essential protocols first, and expanding as resources allow. The workload and cost per protocol can only be estimated at this point. For many of the protocols, several consecutive years of data should be collected before an appropriate sampling frequency and adequate sample size are determined. This approach allows a near-term emphasis on development of key protocol databases, routine reporting formats and finding ways to accomplish data integration.

    - **There was a consensus that the program was attempting to do too much.** Program leaders should meet within the next 2 months to make the difficult decisions about how to prioritize among monitoring components and to determine which components will be included in a core program that can be sustained 'forever'. Criteria for prioritizing among monitoring components might include a) direct application to management and decision-making issues of highest concern; b) clear link to the conceptual models of the Cape Cod ecosystem and maintaining integration across the suite of protocols selected; c) use of established, "tried and true" techniques; d) high signal to noise ratio, i.e. the likelihood of showing a trend if one exists; e) application to the network and the region; f) sustainability, in terms of financial and staffing resources needed and logistics of operations; g) maintaining an appropriate balance between short-term and long-term

management issues and information needs [ideally, data will have immediate value to the public and park administrators as well as value for detecting long-term changes]; h) responsiveness, capability of providing early warning of threats to ecosystems and resources; i) public appeal and marketing value; and j) value as "building blocks" in understanding system or interpreting other data.

- **Articulate managers' needs for information clearly during planning and design of the vital signs program.** Park managers should be involved from the inception of the program in helping to determine what should be monitored, realizing that there must be a balance between tactical monitoring to address immediate management issues and strategic monitoring to provide baseline information for future problems and to detect threats to park resources. Scientists should realize that it is essential to provide information to management that is both useful and timely.

- **Consider adding monitoring of marine sub-tidal areas, including near shore seagrass beds.** The importance of this environment was noted during the review, as well as the difficulty of working there. However, difficult decisions must be made about what monitoring can be accomplished at this time, considering the needs of the park for the information.

- **Consider making a concerted effort to acquire landscape level information for the Cape Cod region and make it more readily available.** Data such as regional population and demographic change, changes in land use, water withdrawals, WWTP loadings, and other similar types of information provide critical context through which the site-specific data is interpreted over time.

- **The proposal to co-locate protocols at Interdisciplinary Monitoring Areas seems like an excellent approach to integrating monitoring activities and improving understanding of linkages across ecosystem and landscape components**. Alternatively, increased effort to clarify and define the area of inference for individual monitoring activities may facilitate broader interpretations and application to other programs and data.

2. **Staffing and Budget. Program leaders should take steps to ensure the long-term financial health of the LTEM program.**

- **Each protocol must identify the human and financial resources required for implementation.** Based upon recent five-year projections for salary expenditures, the monitoring program made some staffing decisions that would allow a proportion of the total budget to remain dedicated to program operations. In order to allocate these resources effectively, it is critical that each protocol include a realistic assessment of staff and budget needs for data collection, analysis, and interpretation. This should include the number and duration of workers needed, any specific skill sets they might require, and startup and routine costs associated with implementation. In turn, monitoring program staff should expand this assessment to determine the appropriate staffing grade levels and appointment authorities, administrative support needs, and periodic infrastructure and logistical support costs, such as vehicle and equipment replacement. Following implementation, there should be a focused effort to track, assess and refine the understanding of actual versus projected implementation costs over time.

- **Consider alternate solutions for accomplishing specialized monitoring projects.** It may be preferable to develop a long-term relationship with USGS, university partners or the Coastal and Barrier Network to maintain the physical science aspects of the program, rather than using a GS5/7 term technician in that capacity.

- **Build safeguards into the monitoring program to ensure program continuity given moderately high staff turnover.** Other prototype programs have found that encouraging two or more staff members to cross-train and collaborate on related projects is an effective way to ensure continuity. Cross-discipline collaboration may also result in stronger integration among monitoring projects.

- **Currently the LTEM program is fortunate to have the NRM Senior Ecologist providing oversight and guidance to the GS7/9 aquatic ecologist position.** Could the significant aquatic portions of the program be sustained if NRM could no longer provide that assistance?

3. **Data Management.**

- **The LTEM Program must develop data-management procedures that facilitate organized data storage, data analysis and integration, and information retrieval**. The Prototype program does not have a data manager or operational procedures for data quality control and analysis. Plans to hire a data manager in FY 2003 will not be enough to solve the problem. In order to resolve the current deficiencies there must be close collaboration between LTEM project managers, the new data manager and cooperators. The ability to effectively integrate monitoring data will hinge in part on early attention to database design and early consideration of integration requirements. Integration issues that need to be resolved early on include identifying core metadata tables and shared look-up tables, standardizing naming conventions and resolving problems associated with disparate temporal and spatial scales.

- **Regularly analyze and report monitoring data to management**. Data are not useful unless they are analyzed and reported in a form that is usable by park management. Although the monitoring efforts are impressive, there appears to be a substantial backlog in data analysis and reporting. Experience at other parks has shown that 30% to 40% of resources should be devoted to data management, analysis and reporting. Recent database improvements are encouraging but much more is needed. The data analysis and reporting backlog must be resolved, and will require the commitment of time and effort by every scientist working with the program, not just the data manager. Standard formats should be developed to routinely report monitoring results for each protocol. The program must provide data summaries and synthesis to managers on a timely basis or the program's value is diminished.

- **Develop a Network data management plan.** The program does not have a data management plan, or a list of products that will be developed by the program. The Northeast Coastal and Barrier Network will be developing a data management plan over the next 1-2 years, and we recommend that the Prototype contribute to and work closely with the network staff to develop a joint data management plan. The plan should include QA/QC procedures to minimize errors.

- **Use relational databases in MS Access for all data sets.** Some of the data sets are in MS Excel or in MS Access databases that are not consistently designed. The Excel spreadsheets have provided a convenient way to enter and interpret the data collected, but are not the best tool to use for long term data sets because of version maintenance and archival. A relational database allows for development of larger data sets with the ability to easily expand the data and link the data to other pertinent data sets. The relational database also allows for powerful linkages to data visualization tools such as GIS or statistical packages that can feed directly from tables or queries within the database. The relational database structure also allows for exporting the data into a flat ASCII file that is recommended for data archival. The 32 monitoring networks are all using the database template approach to developing a relational database structure that links to the Arcview GIS Theme Manager; use of this approach will allow the program to share and compare database components with others throughout the NPS and will increase efficiency and quality of the database design. Each project leader should become well versed in data management standards, and should be the person responsible for ensuring that data are recorded in compatible, standard formats. Database structures should be designed to facilitate integration across protocols, with similar naming conventions, etc.

- **Given the recent history of staff turnover, consider implementing additional measures to ensure an adequate level of documentation**. Two suggestions are: 1) trip reports following each sampling event or season's sampling that describe the scope of the sampling effort, the staff involved, a break-down of field time, a description of field conditions during sampling, description of unresolved problems or unique occurrences, etc.; and 2) a standard server-based file structure for every project to ensure that protocol development work, correspondence, protocol versions, summary reports, analyses and other project-specific documentation are maintained and accessible.

- **Handoff of data from USGS/BRD and university collaborators**. In the absence of a program data manager and established database structures, there may be some concern regarding the handoff of data from principal investigators to the prototype staff. If properly handled, data collected during protocol development will become an important part of the park's baseline. Program staff and cooperators should jointly review each dataset regarding these questions:
    - Are appropriate metadata included (spatial, temporal, observers, methods, units of measurement)?
    - Are codes explained in a data dictionary or lookup table?
    - What nomenclature was used? Are ITIS taxonomic serial numbers also included?
    - What data verification and validation procedures have been employed?
    - Are all data included (raw field forms, relevant spreadsheets or database, spatial files, field notes, etc.)?

**4. Protocol Revision and Augmentation.**

- **Develop a formal process for developing new protocols, adjusting existing protocols, and accepting modifications to improve responsiveness of LTEM program to changing needs.** All protocols developed to date by the USGS staff have been peer-reviewed. Protocols are works in progress. It is only natural that when protocols are implemented in the field, those most familiar with the implementation will develop ideas

for augmentation or revision of standard protocols to improve efficiency or effectiveness. Furthermore, there is often interest to develop new protocols as unmet monitoring needs are identified. This process of continual self-examination and adaptation is both healthy and natural. However, it is imperative that adjustments, revisions, or additions of new protocols not jeopardize the long-term value of data sets or otherwise compromise integrity of the program.

- The process should include a procedure for documenting the need for changes and for identifying when a study plan and peer review is necessary (e.g., changes to sampling frame, changes in monitoring objectives that require development of new sampling frame or procedures). Documentation should identify the need for modification or development of new protocols, the proposed sampling frame, duration of the study, collaborators, and peer review schedule.
- Before beginning any new work on protocol development, the program should require a study plan that undergoes peer review.
- There is a need to develop a procedure for changing protocols and archiving previous versions of a protocol. The NPS has developed a recommended format for what should be included in a protocol, and this recommended format would include a Standard Operating Procedure (SOP) for changing the protocol.
- When a change is made to a protocol, it is essential that the continuity of the data be preserved so that the situation before the change can be compared with the situation after the change. Often this will require that the new and old protocols be used for a few years so that the differences can be estimated.
- Any protocols developed in the future should follow the outline and recommendations in the document "Characteristics of a good monitoring protocol" available at http://www.nature.nps.gov/im/monitor/.
- In the relational Access database, there should be a field added as part of the Events table that documents which version of a protocol was used to collect the data set, and electronic versions of the various versions of the protocol should be easily accessible so that anyone analyzing the data can see how the data were collected.

**5. Reporting and Information Transfer. The LTEM program should establish and adhere to a reporting schedule for transfer of information in different formats to diverse audiences.**

- **Prepare annual reports that provide an overview of current conditions, put the current year in perspective of other years, and alert park management of any threats or concerns.** Program and project leaders have identified potential audiences for LTEM data and information. A high priority should be placed on providing park managers annually with brief, interim reports that identify early warning of possible problems, so that managers can watch for potential problem areas. These reports should be the responsibility of project managers.

- **Periodically conduct detailed analyses and prepare peer-reviewed reports on the status and trends of park resources.** These analyses may discover issues that are not apparent in the annual reports, and they will provide an opportunity for mid-course improvements in the monitoring. The analyses should estimate the power of the monitoring to detect threats to park resources and evaluate the efficiency of the sampling. It would also be valuable to conduct or encourage others to conduct periodic syntheses and interpretation of data from all sources to provide a "state of the park" perspective. Ongoing efforts to integrate monitoring activities notwithstanding, the natural (and easier) tendency will be to analyze data sets independently and not tackle the big picture.

- **Prepare popular reports on the status and trends of park resources and on threats to those resources in cooperation with park interpreters.** Summarize discoveries and

descriptions of ecological processes illuminated by monitoring data for use in public outreach. This information may be critical in developing public support for needed management actions and for developing an understanding of park operations to protect those resources.

6. **Communication.**

- **Operation of the LTEM program should involve close communication and collaboration among the Park Superintendent, the Chief of Resource Management, the Monitoring Coordinator, and the scientific staff.** CACO managers voiced strong support for the value and scientific credibility of the program and the dedication and professionalism of program staff. Although the managers acknowledged the importance of maintaining some separation of LTEM program from day-to-day operations in order to protect program integrity and the role of a prototype, there was concern that the program may be too isolated. Having an operational monitoring program on site provides an opportunity for a fundamental shift in the way the park uses science to make management decisions. It is reasonable to expect that all parties involved (management team, NRM, and LTEM staff) may need to work harder for a time toward communication. The LTEM staff needs to know how best to provide management feedback; park management needs to become familiar with the range of monitoring data, its utility and limitations. Everyone agrees that it is important to maintain the long-term mission of the program. The LTEM staff should also strive to make monitoring results more accessible.

- **Consult with park management regarding the level of monitoring information and formats that would be best suited for various internal and external audiences.** For instance, well-supported qualitative information might be persuasive in dealing with some local issues. More quantitative data would be required to assess whether internal management objectives were being met (e.g. assessing marsh restoration success, or to justify visitor use restrictions).

- **In conjunction with NRM and park management conduct strategic planning to assess how future-monitoring data can be used to address known long-term management issues.** For those issues where multiple datasets are available, a weight of evidence approach may be effective. The superintendent listed groundwater drawdown, visitor carrying capacity (esp. around kettle ponds), and potential impacts if hunting is suspended as important management issues.

- **Conduct frequent meetings (quarterly, reducing to semiannually after 3-5 years) among scientific and managerial staffs to exchange information, concerns, and suggestions regularly.** Communication should be fostered in both directions (managers to scientists and scientists to managers) to help ensure a cohesive team effort that has all staff working on the same goals and objectives. Park managers, program leaders, and scientific staff should work together to identify priority issues and areas of management concern that could be assisted by monitoring efforts.

## Participants in the Cape Cod NS LTEM Program Review

Park Management:

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| Maria Burks | Superintendent, Cape Cod NS |
| Mike Murray | Deputy Superintendent, Cape Cod NS |
| Nancy Finley | Chief, Division of Natural Resource Management, Cape Cod NS |

Cooperators Involved in Program Development:

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| Charles Roman | Research Coordinator, North Atlantic CESU |

Cape Cod NS LTEM Staff:

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| Carrie Phillips | Coordinator for Prototype LTEM program |
| Bob Cook | Wildlife Ecologist |
| Steve Smith | Plant Ecologist |
| Kelly Boland | Wildlife Biotechnician |

Cape Cod NS Natural Resource Management Staff:

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| John Portnoy | Ecologist |
| Krista Lee | Chemist |
| Judith Oset | Lab Technician |

Honored Guests:

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| Steve Thomas | NPS, Mammoth Cave LTEM Coordinator |
| Robert Woodman | USGS, Mammoth Cave LTEM |
| Jamie Bergman | Americorps |

Review Panel:

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| Steven Fancy | NPS, National Monitoring Coordinator |
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